DSN TECHNOLOGY PROGRAM NEWS
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*Welcome to the **DSN Technology Program News**! This quarterly publication will enable us to keep you informed of the latest technology and its diverse applications in the Deep Space Network.*

PROGRAM OVERVIEW

LAIF SWANSON

The DSN Technology Program is divided into (1) the Advanced Technology Development Program, which is concerned with ground issues, and (2) the Systems Development Program, which is concerned with end-to-end communications issues.

In the Advanced Technology Development Program, there are nine distinct *work areas*: (1) Antenna Systems, managed by Mike Thorburn of Section 332; (2) Low-Noise Systems, managed by Jim Shell of Section 333; (3) Network Signal Processing, managed by George Zimmerman of Section 331; (4) Frequency and Timing, managed by John Dick of Section 331; (5) Radio Metric Tracking, managed by Steve Lichten of Section 335; (6) Navigation, managed by Vince Pollmeier of Section 314; (7) Network Automation, managed by Randy Hill of Section 393; (8) DSS 13 Evolution, managed by Mark Gatti of Section 332; and (9) Atmospheric Propagation, managed by George Resch of Section 335.

In the Systems Development Program, there are three areas: (1) Communication

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TRACKING LOW-EARTH SATELLITES

LOWER-COST SATELLITE TRACKING

NASSER GOLSHAN
(FROM A *UNIVERSE* ARTICLE BY DIANE AINSWORTH)

The cost of tracking NASA satellites in low-Earth orbit may be significantly reduced using a fully automated and commercially available satellite-tracking terminal that was recently demonstrated at JPL.

The automated terminal was able to acquire and process telemetry from the Sampex spacecraft, a NASA Small Explorer Program mission in orbit around Earth. The mission is operated by NASA's Goddard Space Flight Center in Greenbelt, Maryland.

This technology demonstration provides a new tool for ground-tracking, which can significantly reduce mission operations costs for near-Earth satellites and, generally, enable lower-cost access to space in the future.

Development of the tracking terminal was carried out by a JPL team led by Drs. William Rafferty and Nasser Golshan.

JPL defined the upgrade requirements to a commercially available weather satellite-tracking terminal and worked with SeaSpace Inc., a terminal manufacturer in San Diego, California, to implement the hardware specifications.

The low-Earth-orbiting terminal was constructed using a SPARC 10 workstation with weather satellite-tracking software and a special interface for monitoring and control of the terminal subsystems. A 3-meter (10-foot) aluminum mesh antenna was enclosed in a fiberglass shell—called a radome—to protect it from rain, winds and other environmental conditions, and set up to track the satellite.

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THE 3-M ALUMINUM ANTENNA IS ENCLOSED IN A FIBERGLASS SHELL (RADOME) AND SET UP TO TRACK LOW-EARTH-ORBITING SATELLITES.

The new tracking system can be easily adapted to a variety of antenna apertures, however, and receiver data rates can be upgraded to speed telemetry readouts. Recurring costs for this receive-only system would fall in the range of $250,000 to $300,000, depending on antenna and receiver options. That cost does not include site preparation, installation, or any additional software required for a specific mission, but it is still significantly lower than the tracking systems currently used.

The tracking system is suitable for a large percentage of NASA's near-Earth missions and compatible with the S-band radio frequency used to monitor many low-Earth-orbiting satellites.

In addition to its greatly reduced cost, the terminal also features a high level of automation. After initial setup, the terminal requires no user intervention. Once per day, the terminal automatically dials up an electronic bulletin board and retrieves orbital elements supplied by the North American Air Defense in Colorado Springs, Colorado., for the spacecraft it will track.

Based on these orbital elements, the terminal automatically generates satellite view periods, antenna-pointing predicts and receiver frequency predicts. If multiple spacecraft are being supported, priorities can be assigned to allow the terminal to resolve scheduling conflicts automatically.

About a minute before a target spacecraft rises above the horizon, the terminal automatically configures itself for that spacecraft's telemetry mode and slews the antenna into position. Data acquisition takes place completely unattended by human operators, although the system can be monitored locally or remotely, using a personal computer running Windows software.

Another innovative feature of the terminal system is its use of commercial data lines. These lines provide a high-quality, low-cost alternative bandwidth link for ground communications support of many NASA missions. This approach allows the use of high quality commercially available services and hardware to interconnect the remote, unattended terminal, the terminal administrator, and the science investigator sites together at low installation and usage costs. Authorized remote users of the terminal have easy access to the system.

In addition to the JPL development team, participants in the demonstration included Dr. Robert Bernstein of SeaSpace Inc., in San Diego, California, which upgraded the weather satellite-tracking terminal; Dr. Glenn Mason, Sampex principal investigator at the University of Maryland; and Jim Williamson, Sampex project operations director at Goddard.

NETWORK AUTOMATION

Automating Monitor and Control

Randall Hill

The Link Monitor and Control Operator Assistant (LMCOA) is an operational software prototype developed to improve the productivity of deep space station operators who perform monitor and control tasks. The LMCOA was recently installed at DSS 13 to support the Ka-band Antenna Performance (KaAP) Experiment. Built on top of the existing monitor and control system at DSS 13, the LMCOA will potentially reduce the number of manual inputs from roughly 900 type-in actions to 3 during a typical 8-hour track.

The LMCOA implements a form of closed loop control over the execution of the procedures used for a pass activity. These control procedures are encoded in a representation called a Temporal Dependency Network (TDN). Whereas the approach to operations taken in the past has been to have the operator manually enter long sequences of directives via a keyboard, subsystem by subsystem, the TDN contains an end-to-end description of the procedures for a pass activity.

The details contained in a TDN exceed what is currently found in the software operator manual (SOM). For instance, the SOM primarily lists a sequence of directives for a particular subsystem without specifying the dependencies of the individual directives or the relationship of one procedure to another, especially among subsystems.

The TDN addresses these issues by representing the preconditions and postconditions of each directive and by providing a means of ordering the procedures, including a way of representing parallelism among the procedures. The LMCOA takes a TDN as input and executes it in the following manner.

Blocks of directives are selected, based on the TDN description, and the preconditions for the selected directives are checked against a device state model. If the preconditions are satisfied, the directives are issued by the LMCOA, and their postconditions are subsequently verified to ensure that the directives had their intended effect on the subsystems. The operator interacts with the LMCOA by watching the TDN as it is executed, and pausing or skipping portions of the TDN that need to be modified for some reason.

When a portion of a TDN fails, the current LMCOA lacks the ability to recover on its own. Instead, the operator needs to decide how to recover from the failure. In the interest of extending the degree of automation at the deep space stations, several improvements and research thrusts are planned for the coming year.

One of the top priorities for the coming year will be to generalize the implementation of the LMCOA so that it can easily support other types of activities besides the KaAP experiment. With later planned versions, an experimenter or project will only need to provide the LMCOA with a sequence of events (SOE) describing the high-level activities for a pass and the LMCOA will select the appropriate TDN and determine a control strategy to meet the requirements of the SOE. In addition, other work will begin to focus on how to automatically recover from certain types of anomalies, which will further reduce the amount of human monitoring required. Finally, we are beginning work on how to effectively store, maintain, and retrieve TDNs from a library. These capabilities will be demonstrated at DSS 13 in the coming year, and will also be used to support ongoing technology transfer activities to the broader Deep Space Network.

The LMCOA reduces the number of type-in actions from 900 to 3.